



## A Study on Green Cloud Computing and Technologies

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**Abstract** — Now a day's data processing power goes hotfoot, therefore we have "Cloud Computing" concept to fulfill this need but some of the harmful gases and chemicals are released contributing to high operational costs and carbon footprints to the environment due to the use of high performance cloud servers for advance computations. A huge amount of power consumptions of datacenters has become a key issue. This key issue leads to one of the contemporary and conspicuous research field "Green Computing", where many researchers are analyzing on providing the productive way to use energy in efficient manner. Green cloud computing is the concept that can not only save energy but also reduce operational cost by using power aware scheduling techniques and minimal virtual machine designs etc. This paper will help the researchers and administrators to have a clear understanding of benefits of green cloud computing. It also discusses the techniques of green cloud computing.

**Keywords**-cloud computing; Green cloud computing; resource management; energy efficiency; virtualization; datacenter; QoS

### I. INTRODUCTION

With the increase number of simultaneous e-commerce transactions and millions of web queries per day there is tremendous rise in the usage of high speed networks over the last decades. This increasing demand leads to the large scale data centers and consolidated servers to fetch the requirements of end users. The commercialization of these developments is defined currently as Cloud Computing [1]. Where computing is delivered as utility on a Pay-as-you go basis. In many IT organizations lot of power is consumed affecting the eco system. Cloud provides the paradigm for virtualization, resource, utilization, management of data centers and environment isolation purposes. The aim of cloud is to derive the design of next generation data centers. By infrastructure them as network of virtual services [2]. So the end user can easily deploy and access the application depending on the requirements anywhere in the world. Cloud thus replaced low level task of setting up basic software and hardware infrastructure and focus on innovation and creating business value for their services. Therefore, maximum IT organizations rely on cloud data centers thus data center management faces the problems of high power and application quality of services. To reduce the power consumption here the term "Green Computing" is introduced that is going green with computers [3]. Green computing is practice of designing, manufacturing using and disposing of computer servers and associated sub system efficiently and effectively with no impact on environment. It represents environmentally responsible way to reduce power and environmental e-waste.

### II. WHY GREEN CLOUD COMPUTING

Green cloud computing is a new technology whose goal is to design better computer system resulting better processing and less energy consumption. As we know now a day's main issue is manufacturing and utilization of such devices which are more efficient and accurate but use more energy and evolve very dangerous gases and chemicals. Lead, mercury, cadmium and other toxic chemicals are used in manufacturing of electronic devices. Due to this reason pollution is increasing very rapidly.

According to Accenture Report [5], there are following four major factors that have enabled the Cloud computing to lower energy usage and carbon emissions from ICT. Due to these Cloud features, organizations can reduce carbon emissions by at least 30% per user by moving their applications to the Cloud. These savings are driven by the high efficiency of large scale Cloud data centers.

#### 2.1 Dynamic Provisioning:

In traditional setting, datacenters and private architectures used to be maintained to fulfill severe demands. Thus, IT companies end up deploying far more infrastructure than needed. There are various reasons for such over-provisioning: a) it is very difficult to predict the demand at a time; this is particularly true for Web applications and b) to guarantee availability of services and to maintain certain level of service quality to end users. To peak load during short period in a year, running hundreds of server throughout the year is not really energy efficient. Thus, the infrastructure provisioned with a conservative approach results in unutilized resources. These can be readily managed by Cloud infrastructure. The virtual machines in a Cloud infrastructure can be live migrated to another host in case user application requires more resources. Cloud providers monitor and predict the demand and thus allocate resources according to demand. Those applications that require less number of resources can be consolidated on the same server. Thus, datacenters always maintain the active servers according to current demand, which results in low energy consumption than the conservative approach of over-provisioning.

## 2.2 Multi-tenancy:

Using multi-tenancy approach, Cloud computing infrastructure reduces overall energy usage and associated carbon emissions. The SaaS providers serve multiple companies on same infrastructure and software. This approach is obviously more energy efficient than multiple copies of software installed on different infrastructure. Furthermore, businesses have highly variable demand patterns in general, and hence multi-tenancy on the same server allows the flattening of the overall peak demand which can minimize the need for extra infrastructure. The smaller fluctuation in demand results in better prediction and results in greater energy savings.

## 2.3 Server Utilization:

In general, on-premise infrastructure run with very low utilization, sometimes it goes down up to 5 to 10 percent of average utilization. Using virtualization technologies, multiple applications can be hosted and executed on the same server in isolation, thus lead to utilization levels up to 70%. Thus, it dramatically reduces the number of active servers. Even though high utilization of servers results in more power consumption, server running at higher utilization can process more workload with similar power usage.

## 2.4 Datacenter Efficiency:

As already discussed, the power efficiency of datacenters has major impact on the total energy usage of Cloud computing. By using the most methodical energy technologies, Cloud providers can significantly ameliorate the PUE of their datacenters. Today's state-of-the-art datacenter designs for large Cloud service providers can achieve PUE levels as low as 1.1 to 1.2, which is about 40% more power efficiency than the traditional datacenters. The server design in the form of commutable containers, water or air based cooling, or advanced power management through power supply optimization, is all approaches that have much improved PUE in datacenters. Also Cloud computing allows services to be moved between multiple datacenter which are running efficient PUE values. This is attained by using high speed network, virtualized services, computation, monitoring and accounting of datacenter.



**Figure 1: Green Model**

Studies shows that most of the data centers don't have sufficient cooling capacity and this is the cause of environment pollution. Green computing deals with the concepts of reducing energy consumption, recycling, eliminate hazardous elements and also deals with reduce in the business travel sharing the resources optimization.

## III. APPROACHES TO GREEN COMPUTING

Minimizing the power usage is main objective of green computing, with escalation in lifetime of product and to make it more efficient. More speed of processors implies more power consumption and their waste heat increases temperature for which cooling is necessary. Environmental responsibility for its own sake might not be topping the priority lists of many cloud providers, but perhaps it should be. That's why high energy consumption results in high operational costs, which eat away at overall profits. Following are the different approaches of green computing.

### 3.1. Green Data Center

The main aim of web hosting providers behind running such huge projects is to differentiate itself from other services through the use of green energy equipment and low power consumption. Data Centers using these types of energy are called as Green Data Centers. This is new trend in web hosting industry, which has a huge demand nowadays. Green data center is a repository for storage management and dissemination of data in which mechanical, lightning electrical and computer systems are design for maximum energy efficiency and minimum environmental impact.

Green energy will continue to become more effective and efficient, and eventually eliminate the sources of energy harmful to the environment. Most of the web hosting providers and data center services are looking forward in this direction, being the world's pioneers in the use of green technology to reduce production costs and environmental impact, rather than

harmful [4]. The construction and opening of green data center include advance technology and schemes. Here are some examples:

- Minimizing the blueprints of the buildings
- The use of low emission building materials in carpets and paints.
- Viable landscaping
- Waste recycling methodologies
- Setting up of catalytic converters on backup generators
- The use of substitute energy technologies such as photo voltaic, heat pumps and evaporative cooling
- The use of hybrid or composite electric company vehicles



*Figure 2: Green Data Center*

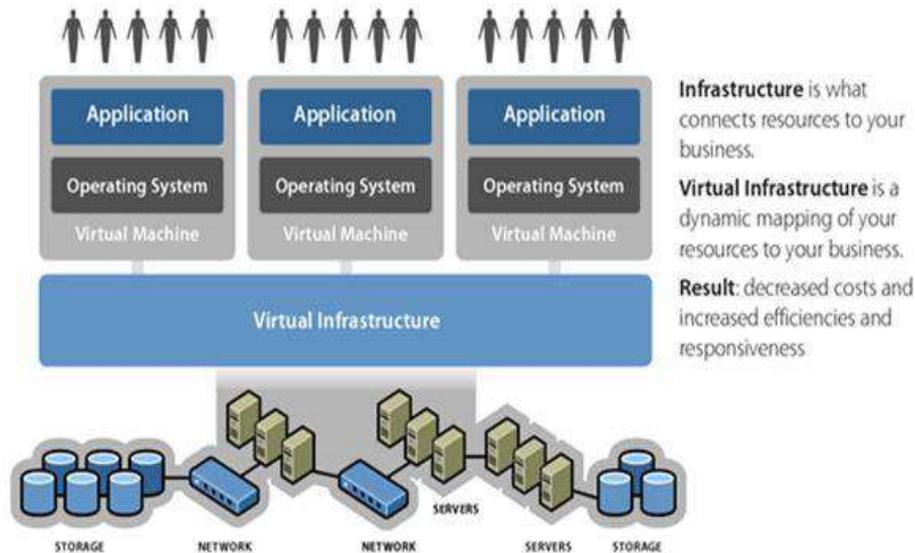
There is growing pressure of environmentalists and increasingly the general public for government to offer green incentives: monetary support for creation and maintenance ecology technologies. Data centers consume the power that can be otherwise use to power thousands of homes. The huge level of power consumption is what make data centers and environmentalists looks for ways to reduce the power used and make data centers for more energy efficient then they currently are.

### **3.2. Virtualization**

Virtualization is the most definite answer for reducing power consumption by data centers, one of the most primary goals of all forms of virtualization is to make most efficient use of available resources. Virtualization makes use of more efficient resources including energy. Defining virtualization in a straight way is that to virtualized means to make a single piece of hardware function as multiple parts. Different user interfaces separately identify different parts of hardware thereby making each one behave and function as an individual separate entity in context of data center virtual infrastructure allows several operating systems and applications to run on lesser number of servers, help to reduce the overall energy use for data center and for its cooling.

Some of the merits of virtualization which directly impacts efficiency and contributes to environment include:

- Planned down time is eliminated by migrating virtual machine from one physical server to another
- Dynamically balance workload across the server group and provided automatic fail over for virtualized applications



**Figure 3: Virtualization and Cloud Computing**

- Resource allocation are more suitably monitored and managed.
- Virtualization gradually increases a server group ability to share resources.
- Server utilization rates can be hiked up to 80% as opposed to initial 10-15 %.

### 3.3. Conserve Energy

The power consumption data for each server was obtained by first calculating the maximum power using HPS power calculators then following the convention that average power use for mid range/ high-end servers is 66% maximum power. The hard disk arrays include supporting functionality such as cache memories, disk array controllers, disk enclosure and redundant power suppliers. In a cloud computing data center all storage space is consolidated and hard disk usage is centrally coordinated. Through server virtualization / consolidation a very large number of users can share a single server which increases utilization and in turn reduces the total users and utilize the server as though they are the only users on the server. During periods of low demand some of the servers enter a sleep mode which reduces energy consumption. To measure efficiency of data center and improve its performance two metrics are known as Power Usage Effectiveness (PUE) and Datacenter Infrastructure Efficiency (DciE)[14].

$$PUE = \frac{\text{OVERALL POWER}}{\text{POWER DELIVERED}} \quad 1 < PUE \leq \infty$$

$$DciE = 1/PUE$$

PUE relates the total consumption of installation with that considered essential to the service: the computer servers (IT load). It is responsibility of IT manager to reduce consumption of IT load and responsibility of infrastructure manager is to reduce auxiliary consumption. Here are some steps to be taken for energy conservation

- Power down the CPU and all peripherals during extended period of inactivity
- Try to do computer related task during contiguous, intensive block of time, leaving hardware off at other time.
- Power up and power down energy intensive peripherals such as laser printers according to need
- Use liquid-crystal-display (LCD) monitor rather than cathode-ray-tube (CRT) monitors.
- Use notebook computers rather than desktop computers
- Use power management features to turn off hard drive and display after several minutes of inactivity
- Minimize the use of paper and properly recycle the waste paper
- Dispose off e-waste according to federal state and local regulations
- Employ alternative energy sources for computing work station, servers, networks and data centers.

### 3.4. Electronic Waste—Reduce, Reuse, Recycle

E-waste is one of the fastest growing waste streams in the world. In developed countries on an average it is equal to one percent of total solid waste. The increasing market penetration in developing countries replacing market in developed countries and high obsolescence rate make e-waste one of the fastest waste stream. In pursuit for faster computers, more

features on smart phones and better picture quality constantly replace electronics with newer and better performing models. There is a way to get improved performance, more features and better picture without increasing the amount of stuff by the concept of sharing resources such as computer memories, processing power and software overall network.



**Figure 4: Reduce: Reuse: Recycle**

To handle the e-waste issue and their effect on environment, the environmental scientist emphasis on three R: Reduce, Recycle, and Reuse process as an alternative to the present e-waste management practice. Different IT companies now a day's looking for other eco-friendly alternatives for industrialization and sustainable development. A lot of reusable gases and elements can be extracted and reuse as these elements are completely recoverable and reusable Recycling or processing e-waste to extract the mineral trapped inside and reusing the rest of component is the viable to solve menace of e-waste. The benefits of e-waste recycling extend to elimination of health and environmental hazard, conservation of resources, energy and efficiency and economic growth.

#### **IV. BENEFITS OF GREEN COMPUTING**

- Reduced energy usage from green computing techniques translates into lower carbon dioxide emission streaming from reduction in the fossil fuel used in power plants and transportation.
- Conserving resources means less energy is required to produce, use and dispose of products.
- Saving energy and resources saves money.
- Green computing even includes changing government policies to encourage recycling and lowering energy used by individuals and business person.
- Reducing the risk existing in the laptops such as chemical known to cause cancer, nerve damage and immune reaction in human.
- Green computing is a big hand to the business persons to improve their corporate image by meetings requirements. It is also good way to meet sustainability.
- Green procurement and asset management is useful for reducing hazardous materials in manufacturing, packaging and factory waste management programs.

#### **V. CONCLUSION**

Overall the effects of green computing with its benefits and practicality are all positives. All which are great for not only the individual but also all around the globe by going "Green" in technology helps to promote eco-friendly and cleaner environment along with benefits of conserving energy, reducing cost on e-waste and green house gases. Even though Green cloud framework has various features to make cloud computing a reliable solution can be made easily:

- 1) First solution can be designing software at various levels by software development strategies and models that facilitates systems wide energy efficiency.
- 2) To implement and use green datacenters, cloud providers should understand and measure existing datacenter power and cooling designs, power consumption of servers, cooling requirements and equipments for resource utilization to achieve maximum efficiency and reducing energy consumption.
- 3) Last but not the least is to provide feasible solutions for scheduling and resource provisioning of applications which in turn will be useful for both service providers and customers to make sure emerging technology is "Green" in terms of usage and also meets the SLAs.

Green computing has definitely come a long way but with so many new innovations among along in regard of preserving the environment. It is safe to say that green computing is a great development for the coming years.

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